BACTERICIDAL TREATMENT OF FOOD STORAGE CONTAINERS BY USING ELECTROCHEMICALLY ACTIVATED BACTERICIDAL AQUEOUS SOLUTION

TECHNICAL FIELD

This invention relates to bactericidal treatment of bio-film in food storage containers. More particularly, the invention relates to bactericidal treatment of bio-film in bulk food storage containers used for fresh produce.

BACKGROUND ART

One of the problems with all fresh produce is their perishable nature and thus their limited shelf life. This is largely due to bacterial contamination and putrefactive enzyme production by the bacteria. A primary source of bacterial contamination is the bacterial bio-film that exists on the inside of bulk storage containers, such as those used on fishing trawlers.

For purposes of this specification, the term "fresh produce" shall be interpreted so as to include fresh foodstuff such as fish, chicken, meat, meat carcasses, processed meat products, processed chicken products, processed fish products and the like.

The use of bulk food storage containers for fresh fish such as those on fishing boats and trawlers, often constituted by the hulls themselves, travelling out to sea for lengthy periods on their fishing trips, is well known. As the fish are caught they are stores typically in crushed ice in the storage containers and hulls of trawlers and boats. Once

sufficient fish have been caught, the trawlers return to harbour where the fish are off-loaded and processed. In many cases much of the preliminary processing, such as "gutting", is done on board out at sea.

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Through the storage of freshly caught fish in these hulls, the fish are exposed to bacterial contamination from the bio-film and the gut residue, thereby reducing the shelf life of the fish.

The use of other bulk food storage containers, such as those used on road and rail transporters for fresh produce such as cattle and sheep carcasses, is similarly well known. In these containers the bio-film on the inside of the storage hulls originates also from blood and gut residue as well as previously contaminated carcasses.

For purposes of this specification, the term "bulk food storage containers" shall be interpreted so as to include containers used for fresh produce such as fresh fish on trawlers, sheep and cattle carcasses on road transporters, rail transporters and the like, and associated terms shall be interpreted so as to have cognate meanings.

Further and for purposes of this specification, the term "transporter" shall be interpreted so as to include fishing ships and trawlers, bulk road

and rail transporters for fresh produce and the like.

OBJECTIVES OF THE INVENTION

It is accordingly an object of the invention to increase the shelf life of fresh produce in bulk food storage containers by overcoming or at least minimising the above disadvantage.

DISCLOSURE OF INVENTION

According to a first aspect of the invention there is provided a method for bactericidal treatment of bulk food storage containers for fresh produce, the method including the step of treating a container with electrochemically activated, bactericidal aqueous solution.

According to a second aspect of the invention there is provided fresh produce, characterised in that it has been treated with electrochemically activated, bactericidal aqueous solution during storage in a bulk food storage container.

According to a third aspect of the invention there is provided a bulk food storage facility, including a bulk food storage container, for fresh produce, the facility being characterised in that it includes means for producing electrochemically activated, bactericidal aqueous solution for

treating an internal surface of the container.

According to a fourth aspect of the invention there is provided a transporter, having a bulk food storage container for transporting fresh produce, the transporter being characterised in that it is provided with means for producing electrochemically activated, bactericidal aqueous solution.

The method may include the step of packing the fresh produce in ice in the container, the ice being characterised in that it is made from an electrochemically activated, bactericidal aqueous solution.

The transporter may be provided with means for providing the aqueous solution in iced form.

The electrochemically activated, bactericidal aqueous solution may be selected from the group consisting of mixed oxidant, anion-containing aqueous solution and mixed reductant, cation-containing aqueous solution.

The electrochemically activated, bactericidal aqueous solution may be prepared by means of electrolysis of an aqueous solution of a salt. The

salt may be sodium chloride. In particular, it may be non-iodated sodium chloride or potassium chloride.

The anion-containing solution and the cation-containing solution may be produced by an electrochemical reactor or so-called electrolysis device, having a through flow electrochemical cell with two co-axial cylindrical electrodes, with a co-axial diaphragm between them so as to separate an annular inter-electrode space into a catalytic and an analytic chamber.The anion-containing solution is referred to hereinafter for brevity as the "anolyte solution" or "anolyte" and the cation-containing solution is referred to hereinafter for brevity as the "catholyte solution" or "catholyte".

The electrochemically activated, bactericidal aqueous solution may be produced from an about 3 to 10% aqueous NaCl solution, electrolysed to produce mixed reductant and mixed oxidant species. These mixed oxidant and reductant species may be labile and after about 96 hours, the various radical species may disappear with relatively no residues being produced.

The anolyte solution may have a redox potential of about between +450mV and +1200mV and a pH of between 2 and 9. The anolyte

solution may include mixed oxidant species such as ClO; ClO^-; HClO; OH^-; HO_2^-; H_2O_2; O_3; $S_2O_8^{2-}$ and $Cl_2O_6^{2-}$.

These species have been found to have a synergistic anti-bacterial and/or anti-viral effect, which is generally stronger than that of chemical bactericides and has been found to be particularly effective against viral organisms and spore and cyst forming bacteria.

The catholyte solution generally may have a pH of between about 12 and 13 and a redox potential of between about -850mV and -900mV. The catholyte solution may include mixed reductant species such as OH^-; H_3^-; O_2; H_2^-; HO_2^-; HO_2^- and O_2^-.

According to a fifth aspect of the invention there is provided equipment for use in a method for bactericidal treatment of bulk storage containers for fresh produce, the apparatus including an electrolysis device, having a through flow electrochemical cell with two co-axial cylindrical electrodes, with a co-axial diaphragm between the two electrodes so as to separate an annular inter-electrode space into a catalytic and an analytic chamber.

Both the physical characteristics of the anolyte and the catholyte, such as pH and redox potential, are adjustable so as to be suitable for a

particular application, such as type of produce, the atmospheric conditions in the container and the like.

BEST MODES FOR CARRYING OUT THE INVENTION

A preferred embodiment of the invention will now be described as a non-limiting example only.

Example 1 :

By using anolyte, it is envisaged that one can achieve an increased shelf life for fish of up to 3 to 9 days. The proposed application of anolyte is as follows:

(a) As ice for storage purposes; and

(b) As a method of eliminating the bio-film on the inside surfaces of bulk storage containers such as those on fishing trawlers and boats.

1.1 Ice

By using anolyte in the form of ice in the storage of fish, the bacterial contamination in the ice is eliminated as well as the contamination of the packed fish. As the ice melts, the anolyte is released to destroy the bacteria.

It is envisaged that the anolyte can be iced either as a concen trate, or in a diluted state with water, varying in dilution from 50% to as low as 20% dilution. The dilution would depend largely upon the contaminated state of the water used in the ice. Some trawlers, for example, use seawater in their ice. Seawater by nature is very contaminated.

The type of anolyte to be used in the ice is :

pH	-	± 7.5;
Amps	-	12 - 13 amps (24 volt);
ORP	-	± 450 mV; and
Pressure	-	0.5 bar (720ml/hr – production rate)

1.2 Bio Film:

Through applying anolyte as a fog within an empty storage container of a trawler, one could eliminate the bio-film and thus the risk of re-contamination of the fish during subsequent use.

The elimination of this bio-film will generally take place between fishing trips, while the trawler is in the harbour with its storage containers empty.

It is envisaged that various methods of application such as fogging could be applied, as long as the droplet size of the fogged anolyte is small (around 4 to 12 micrometers) and the contact time is sufficient. Depending upon the extent of the bio-film, a number of fogging sessions could be required.

Fogging time will also depend upon the size and volume of the container and the output of the fogging apparatus. Generally, one will fog until a thick fog has formed in the closed container and the walls of the container have been sufficiently wet by the anolyte fog so that droplets begin to form and run off (run-off stage). The container would then be allowed to dry before being fogged again.

It is envisaged that the type of anolyte to be used could be:

PH	-	± 6.5;
Amps	-	12 - 13 amps (24 volts);
ORP	-	± 750mV; and
Pressure	-	0.5 bar (± 750 ml/hr - output)

It is envisaged that it could be advantageous also to use anolyte as a general disinfectant in the processing and putting of the fish, of both the process facilities and equipment and the product itself. Anolyte has very limited residue and thus an advantageous over the other disinfectants on the market that are generally chemically based.

Example 2 :

Multiple fogging cycles were used so as to determine the efficacy thereof on the total bacterial surface loads in a series of chillers over a 42 hour chilling period.

Samples 1, 2 and 3 were carcasses fogged separately in chillers with 30 minute intervals. Samples 4 and 5 were carcasses sampled in operating chillers. Foggers were put on the floor of the chillers and carcasses were therefore not fogged directly. 3 x sampling was conducted 42 hours after the previous fogging on all samples so as to establish whether there would be an increase in bacterial loads over the 42 hours prior to de-boning.

Multiple fogging in areas where the fog is not mechanically removed from

the room during the fogging process is highly effective in reducing total counts.

Fogging in operating chillers is not effective.

Throughout the trial Coliform counts were low, most probably due to carcass washing and results therefore were not given.

Example 3:

Enclosed volumes containing diverse equipment, including 2 tables and a scale, were fogged so as to determine the microcidal effect of anolyte on the enclosure surfaces and the enclosed equipment. The results are shown in the accompanying tables.

Example 4 :

Cattle carcasses were treated at the Agricultural Research Council Unit, Irene, Gauteng, South Africa.

The anolyte used was generated under and with the following characteristics :

Current : 10 Ampere; Voltage : 24 Volt

ORP : +762 mV; TDS; 6,04 g/ℓ

PH : 6,8

The chiller treated had volume (space) for about 16 carcasses. The fogging process consisted of 3 cycles of 20 minutes each, with 10 minutes in between each cycle.

Samples were taken from the neck area, the breast area, the back area and the hindquarter area.

Samples were taken of all micro-organisms by means of total plate count (Redoc plates), total plate counts (petri film) and Coliforms (petri film).

The results are shown in the accompanying tables.

Example 5 :

A number of 800 lamb carcasses were subjected to tests, 400 being fogged with anolyte and 400 being used as the control group. Samples

were taken before treatment, after a second cycle and a fourth cycle, while the control group was sampled before and after 24 hours of chilling.

Additional samples were taken from both the treated and the control group for measuring TPC only.

The results are shown in the accompanying tables.

It will be appreciated that many variations in detail are possible without departing from the scope and/or spirit of the invention as claimed in the claims hereinafter.

Example 2: **(New Style Pork)**

Objective:

To determine the effect of multiple fogging on the total bacterial surface loads over a 42 hour chilling period.

	Colony Forming units / 10cm Fogging frequency				Efficacy			Anolyte production Parameters
1	No.	Control	1x	2x	3x(+36h)	% Red.	Log red.	Amp pH
	169	TNTC	12	5	7	99.9	-6	
	236	TNTC	360	3	1	99.9	-6	9 6.66
	168	600	6	3	1	99.9	-2	
	246	110	120	2	1	99.9	-2	24V
	170	13	3	70	0	99.9	-1	1.0 Bar
	99.7	-3.4						
2	189	12	7	1	30	0	0	
	203	100	8	15	0	99.9	-2	12 6.8
	200	140	13	1	0	99.9	-2	
	192	80	2	35	2	97.5	-1	24V
	232	200	6	80	0	99.9	-2	1.0 Bar
	79.4	-1.4						
3	193	TNTC	100	3	2	99.9	-6	
	177	2	30	20	10	0	0	10 5.0
	178	110	70	50	24	78.2	-1	
	179	13	10	6	1	92.3	-1	24V
	180	110	22	11	2	98.2	-2	1.0 Bar
	73.7	-1.8						
4	200	1	4	-	2	0	0	
	211	8	100	-	50	0	0	11 5.0
	1304	5	1	-	0	99	0	
	194	5	8	-	2	40	0	24V
	245	3	4	-	1	33	0	1.0 Bar
	34.4	0						
5	58	1	210	-	TNTC	0	0	
	106	160	120	-	12	92	-2	9 6.66
	68	6	4	-	3	50	-1	
	94	2	60	-	4	0	0	24V
	32	110	90	-	70	27	-1	1.0 Bar
	33.8	.08						

Comments

1, 2 and 3 were fogged separately in chillers with 30 minutes intervals.
Chillers were not in operation. After fogging, carcasses were returned to original chillers.

Example 3 :

Microcidal Effect of Anolyte on Surfaces and Equipment

Surface area	Before cfu/24cm^2	After cfu/24cm^2
Table 1	3	4
Scale	125	27
Floor	33	2
Table 2	31	2
Wall	0	0
Hands	21	0
Saw (Only anolyte was used)	7	0
Table (Only anolyte was used)	10	0

Example 4: (Calf Carcasses)

The test conditions were as follows:

ANOLYTE : 10 Amp
24 volt
+ 762 mV ORP
6.04g/l TDS
6.8pH

Chiller capacity :

No. of carcass in chiller 16

Fogging: 3 x 20 min (10 min rest in between)

Samples taken: Neck area, breast are, back area, hindquarter area

Mico-organisms: Total plate count (Rodac plates)
Total plate counts (petri film)
Coliforms (petri film)

A. Trial Carcasses Direct fogging in chiller with interrupted air circulation during the fogging process

	CFU/10cm^2 – Total Aerobic Count Petri film				
	Before	1 x	2 x	3 x	4 x
V1 Right	168	38	22	18	8
Left		62	---	0	---
V2 Right	58	33	---	2	4
Left		59	---	18	---
V3 Right	330	63	25	0	106
Left		123	---	2	---
V4 Right	156	56	58	8	154
Left		140	---	20	---
V5 Right	220	72	78	19	130
Left		47	---	12	---
V6 Right	175	112	110	16	160
Left		46	---	18	---
Mean R	185	62	59	11	94
L		79	---	12	---
% Decrease		-62	-68	-94	-51

Comments:

The fourth Swab was on the side of the triceps cut where all carcasses had been pushed by hand and were therefore more contaminated than adjoining surfaces.

All swabs were incubated at 37° C for 48 hours
Coliform counts were negligible on all carcasses

B. Negative Control : **Indirect** fogging of carcasses that were present in the chiller, during the time of the experiment. Only final carcass counts on similar locations as the trials were taken.

#	CFU/10cm^2
1	17
2	24
3	5
4	55
5	68
6	14
7	3
Mean	27

Example 5:

Woolworths Trial 800 lamb carcasses

Results:

Treatment with Anolyte

Carcase #	Before treatment			After 2nd fogging			After 4th fogging		
	TPC	Coliform	E.coli	TPC	Coliform	E.coli	TPC	Coliform	E.coli
B33537	180	0	0	-	-	-	0	1	0
B28392	28	0	0	-	-	-	0	0	0
B29673	27	0	1	9	0	0	5	0	0
B30680	19	0	0	0	0	0	0	0	0
B32522	190	14	0	-	-	-	0	0	0
B29535	3	0	0	4	0	0	0	0	0
B28258	18	0	2	5	0	0	1	0	0
B29602	600	0	0	-	-	-	3	0	0
B29505	23	0	0	8	0	0	2	0	0
B28659	25	0	0	-	-	-	0	0	0
Total	**1113**	**14**	**3**	**26**	**0**	**0**	**11**	**1**	**0**
Mean/ 20cm^2	**111.3**	**1.4**	**0.3**	**5.2**	**0**	**0**	**1.1**	**0.1**	**0**

Control group:

Carcase #	Before Chilling				After chilling 24 hrs
	TPC	Coliform	E.coli		TPC
C32592	21	6	0		17
C28363	38	0	0		27
C29469	11	23	0		15
C32540	84	2	0		166
C28309	17	0	0		48
C29137	614	0	0		228
C28588	9	0	0		123
C33039	0	0	0		0
C28333	38	1	1		179
C30032	2	0	0		0
Total	**834**	**32**			**803**
Mean/ 20cm^2	**83**	**3.2**	**0**		**80**

Further swabs were taken on the shoulder of 5 chilled and fogged carcases (after the 4th fogging).

Carcase #	TPC
4BS1	1
4BS2	3
4BS3	0
4BS4	6
4BS5	6
Total	**16**
Mean/20cm^2	**3.2**